LLNL Environmental Restoration Division (ERD)
Standard Operating Procedure (SOP)

ERD SOP 1.2: Borehole Sampling of Unconsolidated Sediments and Rock—Revision: 4

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1.0 PURPOSE

The purpose of this SOP is to ensure acceptable, consistent procedures for collecting discrete soil and rock samples from the vadose zone and several water bearing zones in a single borehole while preventing or minimizing cross contamination of samples.

2.0 APPLICABILITY

This procedure is applicable for all personnel performing borehole sampling, and should be fully reviewed prior to conducting these activities.

3.0 REFERENCES

3.1 American society for testing and materials (1991), *Standard method for penetration test and split-barrel sampling of soils*, astm d: 1586-84, vol. 04.08, 232-237.

3.2 American society for testing and materials (1991), *Standard practice for diamond core drilling for site investigation*, astm d: 2113-83, vol. 04.08, 260-263.

3.3 American society for testing and materials (1991), *Standard practice for ring-lined barrel sampling of soils*, astm d: 3550-84, Vol. 04.08, 445-447.

3.4 Dresen M. D. and F. Hoffman (1986), *Volatile Organic Compounds in Ground Water West of LLNL*, Lawrence Livermore National Laboratory, Livermore, Calif., July 1986, 46 pp. (UCRL-53740).

3.5 Hoffman, F. and M. D. Dresen (1989), *A Method to Evaluate the Vertical Distribution of VOCs in Ground Water in a Single Borehole*, Lawrence Livermore National Laboratory, Livermore, Calif., February 1989, 8 pp. (UCRL-100509, Preprint).

4.0 DEFINITIONS

See SOP Glossary.

5.0 RESPONSIBILITIES

5.1 Division Leader

The Division Leader's responsibility is to ensure that all activities performed by ERD at the Livermore Site and Site 300 are performed safely and comply with all pertinent regulations and procedures, and provide the necessary equipment and resources to accomplish the tasks described in this procedure.

5.2 Hydrogeology Group Leader (HGL)

The HGL's responsibility is to ensure that proper procedures are followed for activities (i.e., drilling, borehole logging and sampling, monitor well installations and development).

5.3 Drilling Supervisor (DS)

The DS plans all drilling related activities and coordinates the drilling contractor schedules and equipment needs.

5.4 Drilling Coordinator (DC)

The DC provides the interface between the DS, Subproject Leader (SL), Hydrogeologist (HG), and the field personnel. The SL or HG provides the Drilling Work Plan and Sampling Plan to the Drilling Geologist (DG).

5.5 Drilling Geologist (DG)

The DG is responsible for conducting all borehole sampling activities safely and correctly per the Drilling Work Plan and Sampling Plan. All applicable operational and safety procedures are to be followed as per this and related SOPs. The DG should inform the HGL, DC, and SL of any nonconformances.

5.6 Subproject Leader (SL)

The SL is responsible for the overall investigation, planning, assessment, and remediation within a study area, including decisions regarding sample depths and analyses required.

5.7 Hydrogeologist (HG)

The HG is responsible for assisting the SL with geologic and hydrogeologic information and decisions regarding sample depths and analyses required.

6.0 PROCEDURES

Borehole sediment and rock sampling is a useful technique for identifying/characterizing the geology, hydrogeology, and sources of contamination, and delineating contaminant distribution in both the unsaturated and saturated zones.

Methods of sediment sampling include driving split barrel samplers and coring. To facilitate sampling for volatile organic compounds (VOCs) in the saturated zone of unconsolidated sediments, standard mud-rotary drilling is employed. In addition, a specialized sampling technique called "Depth Sampling" developed at LLNL (Dresen and Hoffman, 1986; and Hoffman and Dresen, 1989), is used extensively.

It is very important that sampling procedures are followed rigorously so that consistent, high quality analytical data can be obtained. It is essential that the sampling process does not introduce hazardous or foreign substances into the borehole or sample. It is also desirable that the sampling techniques preserve the integrity of all chemicals of interest in their *in situ* concentrations. In practice, these goals may not be fully achieved because the sample is inevitably disturbed somewhat by the mechanics of drilling, sampling, and handling.

6.1 Preparation

6.1.1 Prepare the Drilling Work Plan and Sampling Plan. The SL and HG should review existing geologic and hydrogeologic information to estimate key parameters (e.g., sample target zones, depth, and thickness and types and concentrations of contaminants, etc.) and discuss sampling strategy. The DG should fill out a Drilling Work Plan Summary Sheet and a Sampling Plan Summary Sheet (Attachment E). The Sampling Plan Summary Sheet should include number and depth of samples to be collected, sample identification name, turnaround time, analyses, and analytical laboratory.

6.1.2 Review the Drilling Work Plan and Sampling Plan. The plans should be reviewed by the DG, DC, DS, a member of the Data Management Team, and a QC Chemist. The SL or HG should e-mail the plan to these personnel at least one week before drilling is scheduled to begin. The DG should meet with the SL and/or HG to discuss site conditions before drilling begins.

6.1.3 Perform the applicable preparation activities described in SOP 4.1, "Instructions for Field Personnel."

6.1.4 Obtain materials listed in the Equipment Checklist (Attachment A) and obtain the appropriate personal protection equipment (PPE) (SOP 4.1).

6.1.5 The DG should obtain a Field Sampling Logbook to record sample numbers and Chain-of-Custody (CoC) document numbers per SOP 4.2, "Sample Control and Documentation."

6.2 Split-Barrel Sampling

6.2.1 Wash split-barrel sampler with detergent and analyte-free water (source should be analyzed to determine analyte-free status), and rinse, or steam clean per SOP 4.5, "General Equipment Decontamination." Collect a rinesate/equipment blank, from the interior of the sampler and submit for analysis per SOP 4.9, "Collection of Field QA/QC Samples" when deemed necessary by the SL or HG. The SL or HG shall determine the necessity and frequency of equipment blanks during drilling activities.

6.2.2 Remove cuttings/slough from borehole and center plug.

6.2.3 Sample collection for volatile and semivolatile organic compound analysis:

A. Load precleaned (steam cleaned, de-ionized rinse) brass or stainless-steel tubes into a split-barrel sampler. After the driller is certain all slough is removed from the auger and borehole, drive the sampler to desired depth in borehole.

B. To maximize sample integrity, collect the sample from the deepest tube, provided quality is good (i.e., no headspace).

C. Quickly observe lithology, seal the tube ends with Teflon tape, high-density polyethylene caps, and secure with duct tape.

D. Use an indelible marker to label the sample with identification (borehole/well number followed by top of sample depth), sampling date, sample time, analysis type(s), and sample collector's initials per SOP 4.2. Both end caps and the duct tape should be labeled.

E. Immediately place the sample tube in a plastic bag and seal by tying a knot in the opening. To keep samples dry, double bag. Double bag sets of samples when cross contamination is not a concern.

F. To facilitate rapid cooling, all samples should be placed in an insulated cooler containing bagged ice. Ice melt water is to be drained from the cooler throughout the day, and all loose ice is also double bagged at the end of the day for courier delivery to the analytical laboratory. Blue Ice coolant packs should be used for shipping samples through the LLNL Shipping Department.

G. Document sample identification, time and date of sample, location, turnaround time, and analysis type(s) on the Borehole/Well Construction Log (Attachment A).

6.2.4 Sample collection for metal, high explosives (HE), and radiological analysis:

A. Load tubes into split-barrel sampler and drive sampler to desired depth in borehole. Stainless steel sample tubes should be used during metals sampling to prevent metal cross contamination.

B. Record lithology, seal the tube ends with Teflon tape, and secure with duct tape. Alternatively, sample can be transferred to a wide-mouth glass jar and sealed with duct tape.

C. Use an indelible marker to label the sample tube or jar with the identification (borehole/well number followed by top of sample depth), sampling date/time, sample analysis type(s), sample collector's initials per SOP 4.2. Both end caps and the duct tape should be labeled.

D. Place the sample tube or glass jar in a plastic bag and refrigerate as described in 6.2.3 E.

E. If tritium analysis is to be performed, immediately refrigerate the sample tube or jar in plastic bags in an insulated cooler. If a jar is used, ensure that the jar is packed tightly to reduce air space, and that the lid is closed tightly and taped to help seal. If the samples are not immediately shipped to the analytical laboratory, they should be stored in a refrigerator. Samples held overnight will be transferred to a freezer.

F. Document sample identification, time and date of sample, location, turnaround time and analysis type(s) on the Borehole/Well Construction Log (Attachment A).

6.3 Coring

6.3.1 Wash core barrel with detergent and water approved by the ECBGL, and rinse with clean water, or steam clean as per SOP 4.5. Collect a rinesate/equipment blank from the core barrel and submit for analysis as per SOP 4.9, "Collection of QA/QC Samples," when necessary.

6.3.2 Insert core barrel and core 5 ft or less.

6.3.3 Retrieve the core barrel with a wireline overshot device immediately. Place the core in a clean polyvinyl chloride (PVC) core tray, ensuring that the core remains in stratigraphic sequence.

6.3.4 Collection of samples for VOC analysis.

A. Quickly observe lithology. Place a core segment of lithified sediment or rock approximately 3 to 6 in. long in stainless steel or brass cylinder tubes. Seal the ends with Teflon tape, cover with high-density polyethylene caps, and secure with duct tape. Wide-mouth glass jars sealed with duct tape may be used if specified in the Sampling Plan.

B. Use an indelible marker to label the sample with identification (borehole/well number followed by top of sample depth), sampling date/time, analysis type(s), and sample collector's initials per SOP 4.2. Both end caps and the duct tape should be labeled.

C. Immediately place the sample in a bag, and refrigerate in an insulated cooler (Section 6.2.3 E).

D. Document sample identification, time and date of sample, location, turnaround time, and analysis type(s) on the Borehole/Well Construction Log (Attachment A).

6.3.5 Collection of samples for metal, HE, and radiological analysis.

A. Record lithology, wrap a core segment of approximately 3 in. with inert plastic tubing in an air-tight plastic bag or in a wide-mouth glass jar, and seal with duct tape. Note: the sample must be packed tightly to reduce air space. Other acceptable sample containers are stainless steel or brass cylinder tubes. If these are used, seal the ends with Teflon tape, cover with high-density polyethylene caps, and secure with duct tape.

B. Use an indelible marker to label the sample with the identification (borehole/well number followed by top of sample depth), sampling date/time, sample analysis type(s), sample collector's initials, and LLNL/project name (optional).

C. Place the wrapped core segment, glass jar, or soil sample tubes in sealed bags and refrigerate as previously described in Section 6.2.3 E.

D. If tritium analysis is to be performed and samples are not shipped out immediately, samples should be transferred to a refrigerator at the end of the day, or a freezer if held overnight.

E. Document sample identification, time and date of sample, location, turnaround time, and analysis type(s) on the Borehole/Well Construction Log (Attachment E).

6.3.6 Store remainder of core in boxes per SOP 1.15, "Well Site Core Handling."

6.4 Depth Sampling—Livermore Site

"Depth Sampling" uses the mud-rotary drilling technique and a 94-mm wireline punch-coring system. This technique enables the collection of samples from several water-bearing zones in each borehole while preventing or minimizing cross contamination. The technique is utilized effectively when VOC concentrations are moderate to low (i.e., generally less than about 10 parts per million [ppm]). Attachment F is a schematic diagram of punch-coring and depth sampling that shows a water-bearing zone encountered after sampling and drilling through two "shallower" water-bearing zones containing VOCs. During the drilling a mud cake forms along the borehole sidewall, which restricts the water flow from the upper water-bearing zones into the hole. In addition, the relatively dense drilling mud penetrates the formation and further restricts water flow into the borehole from the formation. These effects tend to isolate and therefore "protect" deeper water-bearing zones from the VOCs. The following procedures are used:

6.4.1 Only pure (i.e., non-beneficiated) bentonite and potable water from source(s) approved in advance by the project ECBGL are to be used.

6.4.2 Upon encountering a new water-bearing zone, the sampler is removed with a wireline while the drill rod remains in the borehole, and new mud is mixed in a dedicated tub. The new mud, pumped into the drill rod, displaces the old drilling mud, which may contain VOCs, into the annular space outside of the drill rod (Attachment F). The mud tub at the surface collects the spent mud and, subsequently, the cleaned core barrel, per SOP 4.5, is deployed through the new drilling mud to prevent contamination of the sampling equipment with VOCs that may have been in the previous drilling mud.

6.4.3 Core drill 1 to 2 ft to collect a sample of the sediment for chemical analysis (Attachment F).

6.4.4 Retrieve the core barrel with a wireline overshot device.

6.4.5 To minimize potential displacement of pore water in the sample, retain the bottom-most tube for chemical analysis. If significant void space or drilling mud penetration is evident, discard the sample and collect and retain the next suitable sample.

6.4.6 Permeable lenses (<3 ft thick) may be sampled by quickly "stuffing" sediment core into a brass sample tube and noting the location on the borehole log.

6.5 Post Operation

6.5.1 Perform post-work activities described in SOP 4.1, Section 6.3.

6.5.2 Collect, inventory, and prepare all samples for shipment, per SOP 4.4, "Guide to the Handling, Packaging, and Shipping of Samples."

6.5.3 Fill out CoC forms and shipping forms per SOP 4.2.

6.5.4 Record a daily summary of drilling and sampling in the Field Sampling Logbook per SOP 4.2, and on the Daily Field Report (Attachment C).

6.5.5 Deliver all original forms and logbooks to the DMT for storage. Provide the DC copies for review and distribution.

7.0 QUALITY ASSURANCE RECORDS

7.1 Borehole/Well Construction Log

7.2 Chain-of-Custody Form

7.3 Document Control Logbook

7.4 Daily Field Report

7.5 Soil Analyses Form

7.6 Drilling Work Plan

8.0 ATTACHMENTS

Attachment A—Borehole/Well Construction Log

Attachment B—Soil Analyses Form

Attachment C—Daily Field Report

Attachment D—Drilling Geologist Equipment List

Attachment E—Drilling Work Plan Summary Sheet and Sampling Plan Summary Sheet

Attachment F—Schematic Diagram of Depth Sampling and Punch Coring

Attachment A

Borehole/Well Construction Log

Borehole/Well Construction Log

(1) BOREHOLE LOCATION	**(2)** Project:	**(3)** Borehole/Well No.:
		(4) Job No.:
	(5) Logged By:	**(6)** Edited By:
	(7) Project Manager:	**(8)** Drill Rig:
	(9) Drilling Contractor:	
	(10) Driller/Helper:	
	(11) Drilling Method:	**(12)** Sample Method:
	(13) Hammer Weight/Drop:	**(14)** Bentonite Gel Used:
	(15) Borehole Diameter, Pilot:	Final:
	(16) Borehole Started, Time/Date:	**(17)** Borehole Completed, Time/Date: **(18)** Water Source:
Notes:	**(19)** Well Started, Time/Date:	**(20)** Well Completed, Time/Date:
	(22) Water Depth / Boring/Casing Depth / Time / Date	**(21)** Well Head Completion

ABBREVIATIONS: ------- = Approx. Contact; //////// = Gradational Contact; @ = at; _____ = Definite Contact; 1 K = primary conductivity; 2 K = secondary conductivity due to fracturing, mineralization, etc.; A = angular; bl = blue; blk = black; brn = brown/brownish; c = coarse; calc = calcite; CIF = coring induced fracture; cmt = cemented; DA = Drill Ahead; def'm = deformation; DF = drilling fluid (mud); dk = dark; E = estimated; f = fine; FeOx= iron oxide; grn = green/greenish; gry = gray/grayish; H = high; HF = healed fracture; HIF = handling induced fracture; ind = indurated; K = Hydraulic conductivity; L = low; lt = light; m = medium; min = mineralization; MnO2 = manganese oxide; mod = moderate; NF = natural fracture; NR = No Recovery; P = plasticity; PC = punch core; ppm = parts per million; qtz = quartz; R = rounded; RC = rock core; RQD = rock quality description; rx w/HCI = reaction with hydrochloric acid; S = sub; SA = subangular; soft sed = soft sediment deformation; SR = subrounded; SS = split spoon; v = very; w/ = with; x-beds = cross beds; ylw = yellow/yellowish.

(30) OVA/PID Field Readings (ppm)		**(31)**	**(32)**	**(33)**	**(34)**	**(35)**	**(36)**	**(37)**	**(38)**	**(39)**	**(40)**	**(41)**	**(23)** Total Depth:	**(24)** Casing Depth:
													(25) Screened Interval:	
													(26) Sand Pack, #3	#0/30:
													(27) Well Development Method: Time: Date:	Flow Rate:
													(28) Geophysical Logs, Type: By: Date	**(29)** Circulation:
Work Area	Soil/Rock	Sampler Type/Depth	Blows 6 inches	Inches Recovered/Inches Driven	(Sample Condition/RQD	Sample ID	Analysis	Well Annulus/Borehole Filler	Well Casing	Depth in Feet	Recovery/Sample Loc.	Contact	**(42)** LITHOLOGIC DESCRIPTIONS	
										1				
										2				
										3				
										4				
										5				
										6				
										7				
										8				
										9				
										10				

Note: Numbers **1–42** listed on this log correspond to Subsections **6.4.1–6.4.42** of SOP 1.1.

Attachment A. Borehole/Well Construction Log.

------- = Approx. Contact; //////// = Gradational Contact; @ = at; _____ = Definite Contact; 1 K = primary conductivity; 2 K = secondary conductivity due to fracturing, mineralization, etc.; A = angular; bl = blue; blk = black; brn = brown/brownish; c = coarse; calc = calcite; CIF = coring induced fracture; cmt = cemented; DA = Drill Ahead; def'm = deformation; DF = drilling fluid (mud); dk = dark; E = estimated; f = fine; FeOx= iron oxide; grn = green/greenish; gry = gray/grayish; H = high; HF = healed fracture; HIF = handling induced fracture; ind = indurated; K = Hydraulic conductivity; L = low; lt = light; m = medium; min = mineralization; MnO2 = manganese oxide; mod = moderate; NF = natural fracture; NR = No Recovery; P = plasticity; PC = punch core; ppm = parts per million; qtz = quartz; R = rounded; RC = rock core; RQD = rock quality description; rx w/HCI = reaction with hydrochloric acid; S = sub; SA = subangular; soft sed = soft sediment deformation; SR = subrounded; SS = split spoon; v = very; w/ = with; x-beds = cross beds; ylw = yellow/yellowish.

(30) OVA/PID Field Readings (ppm)		**(31)**	**(32)**	**(33)**	**(34)**	**(35)**	**(36)**	**(37)**	**(38)**	**(39)**	**(40)**	**(41)**	**(2)** Project:	**(3)** Borehole/Well No.:
Work Area	Soil/Rock	Sampler Type/Depth	Blows 6 inches	Inches Recovered/Inches Driven	Sample Condition/RQD	Sample ID	Analysis	Well Annulus/Borehole Filler	Well Casing	Depth in Feet	Recovery/Sample Loc.	Contact	Notes:	
										1				
										2				
										3				
										4				
										5				
										6				
										7				
										8				
										9				
										0				
										1				
										2				
										3				
										4				
										5				
										6				
										7				
										8				
										9				
										0				

Note: The numbers listed in parentheses on this log correspond to the Subsections listed in Section 6.4 of SOP 1.1 [i.e., **(2)** = **6.4.2**, etc.].

Attachment A. Borehole/Well Construction Log (cont.).

Attachment B

Soil Analyses Form

Initials _____

Job No. _____

Saturated Soil Analysis from Boring B-____ **Page __ of __**

Sampling date	Depth (ft)	Water-bearing zone	Soil type (USC)	Sample quality (P,F,G,E)	Analytic Method	Turn-around time	TCE	PCE	1,1-DCE	CCl_4	mg/kg (ppm)				Lab log no.	Bulk density (g/cm^3)

Other Bulk Density Sample Available _____

TOC Samples Available _____

Attachment C

Daily Field Report

DAILY FIELD REPORT

Date	Project(s):
Name:	Project Manager:
Vehicle:	Job Number:

PID/OVA Calibration: Yes _____ No _____	Daily Site Safety Meeting Time _____
Time: _____	

Time	Activity

Attachment C. Daily Field Activity. **10-00/ERD:rtd**

Attachment D

Drilling Geologist Equipment Checklist

Drilling Geologist Equipment Checklist

____ 300-ft weighted tape
____ Any applicable permits (i.e., excavation, utility clearance, burn permits)
____ Applicable documents (i.e., SSP, OSPs, SOPs, work plan, sample plan, etc.)
____ Appropriate clothing (i.e., coveralls, steel-toed safety shoes, gloves)
____ Barricades/traffic cones
____ Buckets and brushes
____ Caution tape
____ Company ID sign for vehicle
____ Cooler with ice
____ Core boxes, marking pens
____ Deionized water
____ Detergents (Alconox, Liquinox)
____ Disposable Teflon or polyethylene bailers
____ Document control logbook
____ Field forms (i.e., borehole/well constructions form, daily field report forms)
____ Field notebook
____ Fire extinguisher
____ First aid kit
____ Glass jar
____ Grain-size sieves
____ Hard hat
____ Hearing protection
____ Imhoff cone
____ Measuring wheel
____ Munsell soil/rock color chart
____ Nitrile or latex sampling gloves
____ pH paper
____ PID or FID, or gamma/beta meter if required
____ Rock hammer
____ Safety glasses
____ Sample containers/labels
____ Signs listing responsible persons, restricted entry, hearing protection/hard hat/safety glasses/safety shoes required
____ Soil sample tubes
____ Steel measuring tape with engineering scale
____ Steel spatula
____ Stopwatch or watch with second hand
____ String
____ Teflon tape (4 in. wide)
____ Water-level meter
____ Zip-Loc plastic bags

Attachment E

Drilling Work Plan Summary Sheet and Sampling Plan Summary Sheet

DATE

TO: **Drilling and Supervising Geologists**
FROM:
SUBJECT: **Drilling Summary Sheet**

This drilling work plan summary sheet describes activities related to the planned borehole(s)/well(s) in the table below. Monitor well completion details will be determined by the drilling supervisor and project manager based on analytic and hydrogeologic information collected during drilling.

Borehole/well name	Purpose

Site Geology and Hydrogeology

Table 1. Units expected to be encountered.

Geologic unit	Approximate depth	Anticipated hydrogeology

Table 2. Information from nearby wells. See attached map for locations.

Well	Well depth (ft)	Approximate depth to water (ft)	Screened stratigraphic Unit	Completion depth (ft)	Maximum concentrations in ground water (ppb)

Drilling Methods and Procedures
- Drill with hollow-stem augers at least 5 ft into hard rock.
- Install surface casing after penetrating 5 ft of rock if required for borehole stability,
- Continue boreholes through hard rock to a maximum depth of 55 ft using 94-mm wireline coring. Total borehole depth will be determined by the DS and PM.
- If water is encountered, continue drilling 3 to 5 ft into the next fine-grained sequence. Contact the DS and PM to discuss well completion.

Sampling
- Samples will be collected at least every five feet and at lithologic changes. A sample from each interval will be analyzed for VOCs by EPA Method 8010.
- Several samples will also be analyzed for metals, petroleum hydrocarbons, high explosives, nutrients (nitrates), and radioactivity as described in the attached sampling plan(s) .
- After reviewing analytical results from the first borehole, the DS and PM may revise the sampling plans for the remaining boreholes.

DNAPL Testing
- A field test for DNAPLs should be performed if (1) abnormally high hits of VOCs are identified by PID, (2) an odor is evident, or (3) high VOC concentrations are expected based upon results of SVS sampling or previously drilled boreholes. A protocol for this procedure is being prepared by Stephen Vonder Haar.

Geophysical Logging
- Natural gamma, electromagnetic induction, and caliper logs may be run on each borehole as deemed appropriate by the DS and PM.

Monitor Well Installation
- Monitor well installation decisions will be made by the DS and PM based on evaluation of any encountered ground water zones.
- The regulators must approve well design before well installation can begin.

Site-Specific Issues
- Screen drilling fluids and cuttings daily as described in "Field Screening of Drilling Waste for Purgeable Halocarbons (TCE, PCE, DCE, etc.)."
- Because drilling will take place in a limited area, personnel without L or Q clearance must be escorted on site.
- Consult the SOPs for elaboration on any of the procedures described in this work plan.

Figure(s), Sampling Plan(s), and Other References
- Map of Proposed Borehole Locations (Figure 1)
- Sampling Plan(s)

Refer also to documents listed below:
- Field Screening of Drilling Waste for Purgeable Halocarbons (TCE, PCE, DCE, etc.).
- SOPs Applicable to 832 Canyon OU Characterization Plan Activities
- SOPs for Segregation of VOC-Contaminated Drilling Spoils at LLNL Site 300
- General Site Procedures

SAMPLING PLAN SUMMARY SHEET

Drilling Geologist/Engineer _____ Drilling Geologist/Engineer _____

Estimated Borehole Depth _____ Start Date/Time _____

Purpose(s) _____

Location _____

DRILLING METHOD

Unsaturated Zone		Saturated Zone	
_____			Air Rotary
_____			Mud Rotary
_____	Other _____	_____	Other _____

LITHOLIGIC SAMPLING AND LOGGING (check appropriate items)

Unsaturated Zone

_____ Log by cuttings, fluid pressure, driller input, etc. only (no lithologic sampling) from _____ to _____ ft

_____ Limited lithologic sampling: Collect samples from _____ to _____ ft or _____

_____

_____ Sample approximately every 10 ft and at material changes: log by cuttings between samples

_____ Other: _____

Saturated Zone

_____ Log by cuttings, fluid pressure, driller input, etc. only (no lithologic sampling) from _____ to _____ ft

_____ Limited lithologic sampling: Collect samples from _____ to _____ ft or _____

_____

_____ Sample approximately every 10 ft and at material changes: log by cuttings between samples.

_____ Continuously core

_____ Run routine suite of geophysical logs (natural gamma, caliper, spontaneous potential, point resistivity and 6 ft lateral

_____ Other: _____

CHEMICAL SAMPLING (check appropriate items)

Unsaturated Zone

_____ No chemical sampling

_____ Sample at about _____

_____ ft

for the analyses listed in Table 1

Saturated Zone

_____ No chemical sampling

_____ Sample ALL water-bearing zones for the chemical analysis list in Table 2

_____ Sample ONLY the following water-bearing zones for the chemical analyses listed in Table 2

_____

_____ Sample confirming layers between water-bearing zones as described below for the chemical analyses listed in Table 2 _____

_____

_____ Other: _____

Table 1: Unsaturated Soil Samples			
Sample depth (ft)	Turnaround Time: R = Rush H = Hold N = Normal	Analytical laboratory	Type of analysis
Special instructions:			

Table 2: Saturated Soil Samples			
Sample depth (ft)	Turnaround Time: R = Rush H = Hold N = Normal	Analytical laboratory	Type of analysis
Special instructions:			

Sampling Plan Approved by:

Subproject Leader _____

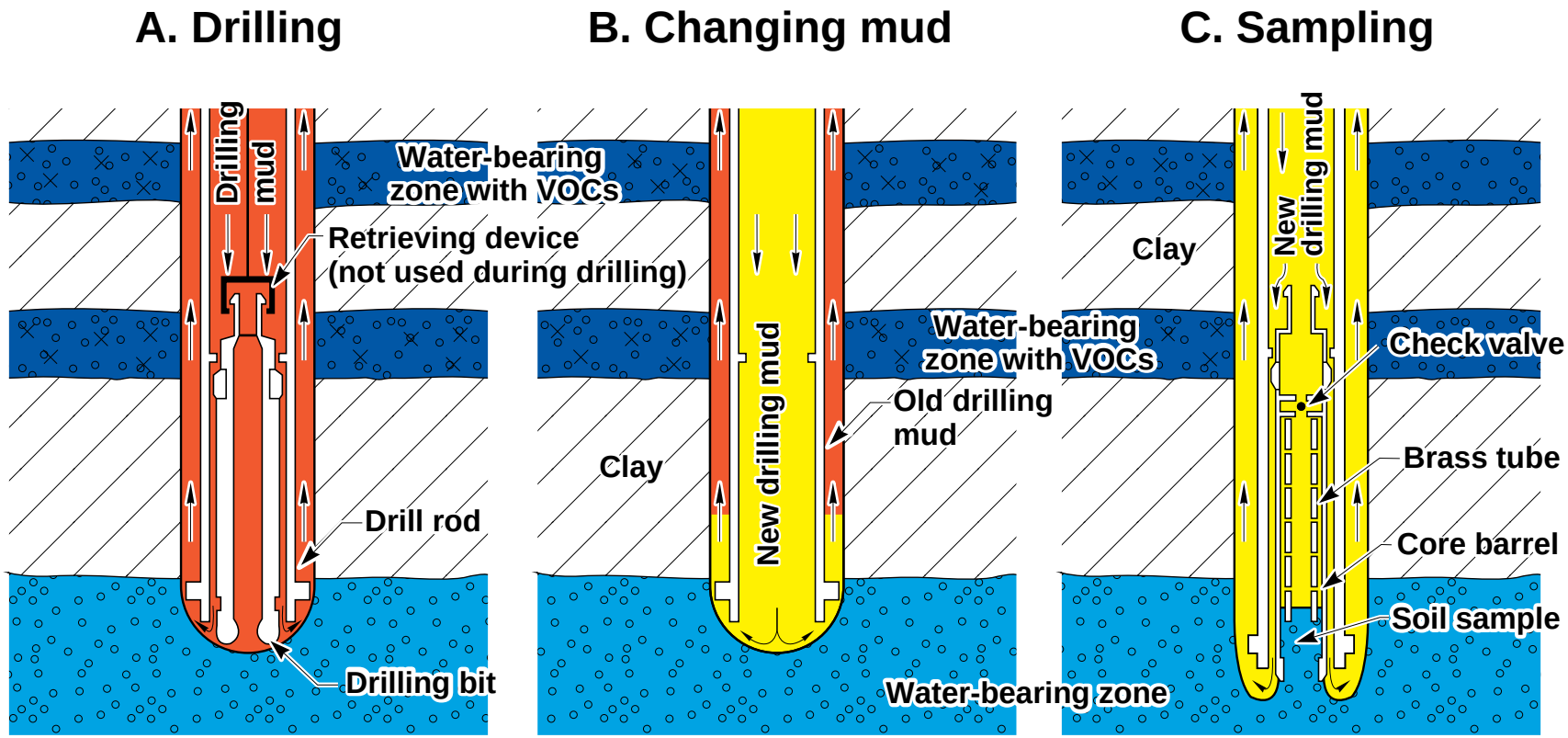
Initials/Date

Drilling Supervisor _____

Initials/Date

Attachment F

Schematic Diagram of Depth Sampling and Punch Coring



Attachment F. Schematic diagram of depth sampling and punch coring (Dresen and Hoffman, 1986). Arrows indicate direction of mud circulation.